THE PITUITARY GLAND OF THE AFRICAN LUNGFISH, PROTOPTERUS AETHIOPICUS

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Information on the histology of the pituitary gland of the Dipnoi is fragmentary. The early development of the gland in *Lepidosiren* was described by J. G. Kerr (1902) and a sagittal section of the adult organ was included by de Beer (1926) in his monograph on the comparative morphology of the pituitary. Later T. Kerr (1933) gave a more complete account of the embryology of this organ in *Lepidosiren* and included a brief description of the histology of the adult gland. This material had been preserved in formalin for a long time and consequently was not favorable for detailed histological analysis.

Griffiths (1938) has added some additional notes on the development of the pituitary in *Lepidosiren*. His attention, however, was devoted chiefly to the Australian lungfish, *Epiceratodus* (*Neoceratodus*) *forsteri*, and he gave a short account of the development and histology of the gland in this form. Except for a brief reference by J. G. Kerr (1902) to an embryonic stage, the pituitary of *Protopterus* seems to have escaped histological study.

In *Epiceratodus, Lepidosiren* and *Protopterus* the epithelial portion of the gland develops as a solid wedge of epithelial cells derived from the stomodaeal epithelium. This ingrowth extends caudally and comes to lie beneath the brain in a region posterior to the future optic chiasma. Later, a cavity develops within the solid ingrowth and the connection with the superficial ectoderm is lost. The epithelial hypophysis now flattens and elongates to become intimately associated with the postero-ventral surface of the infundibulum. Apparently lateral lobes are not developed and the pars tuberalis accordingly is absent in the adult organ.

In *Epiceratodus,* only the anterior end of the epithelial hypophysis is closely appressed to the infundibulum. In *Lepidosiren,* and probably in *Protopterus* also, the entire dorsal surface of the elongated epithelial rudiment is applied to the infundibulum. In *Epiceratodus* the epithelial hypophysis "along the whole of its length, curls around and becomes

intimately united to the posterior face of the infundibulum. The cells of the caudal tip become the pars intermedia, whilst growth of the hypophysis, ventral to the hypophysial cavity, results in the large pars anterior" (Griffiths, 1938). However, in the adult the infundibulum is no longer directed backwards but extends vertically from the floor of the brain into a deep sella turcica so that the pars anterior eventually occupies a true anterior position.

In *Lepidosiren* (Kerr, 1933) the portion of the epithelial hypophysis dorsal to the cavity and in contact with the infundibulum remains rela-

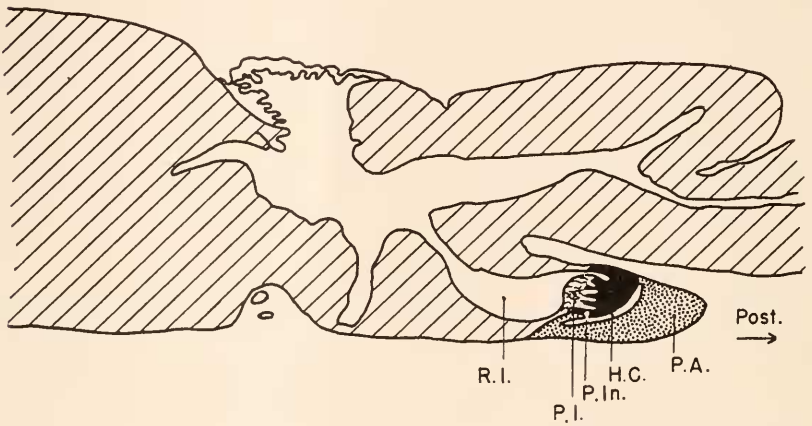

FIG. 1. Diagrammatic sketch of a sagittal section of the brain of *Protopterus* showing the relation of the pituitary gland to the infundibulum. The regional differentiations within the pituitary are also represented: *R.I.*, recessus infundibularis; *P.I.*, processus infundibularis; *P.In.*, pars intermedia; *P.A.*, pars anterior; *H.C.*, hypophysial cavity. × 9.

tively thin and the boundary between the nervous and epithelial component is soon broken down. Ventral to the cavity the gland is greatly thickened. These two epithelial differentiations foreshadow the pars intermedia and pars anterior respectively. However, de Beer (1926) fails to show a cavity in the adult pituitary of *Lepidosiren* (Fig. 70). There is apparently little change in the relative position of the infundibulum in the adult. It is directed ventro-caudally with the epithelial components lying ventral to the neural lobe. The adult gland is a wedge-shaped organ attached at its broad end to the tip of the infundibulum and sunk into a shallow depression in the cranial floor.

Materials

This study of the pituitary of *Protopterus* is based on two male fish (14 inches long) which were obtained from the General Biological Supply House, Inc. and kept in the laboratory for several months. One died at night and the pituitary was dissected out and fixed the following morning. The other was killed and the tissue fixed immediately. In both cases formol-sublimate was used. The glands were left attached to the floor of the brain and were sectioned sagittally. All tissue was stained by the azan method of Heidenhain. The fixation was excellent in the freshly fixed gland but some cytolysis had occurred in the other which was not obtained until several hours after death.

Description

In a ventral view of the brain only the infundibular process and the flattened, ovoid pars anterior of the pituitary are visible (Fig. 2). The gland lies close to the brain and the floor of the cranium is not depressed in this region to form a sella. The pituitary is located well posterior to the optic chiasma and is directed caudally. Its topographical relation to the brain is clearly seen in sagittal sections (Fig. 1). The infundibular process is wide and flattened, well delimited from the floor of the brain and projects caudally. The portion of the process associated with the epithelial component of the gland is thin-walled except in a medial postero-ventral region applied to the pars intermedia, where a considerable thickening occurs. The thickening is due to a local massing of fibrous tissue apparently similar to that of the posterior lobe of other vertebrates (Fig. 3). Irregular slender outgrowths from the saccular infundibular recess invade the compact tissue. They appear to be homologous with the so-called sinuses in *Lepidosiren* (Kerr, 1933) and are readily distinguished from empty blood vessels by the ependymal lining.

The epithelial portion of the pituitary possesses a conspicuous hypophysial cavity which incompletely separates an antero-dorsal intermediate zone from a flattened, elongated ventro-caudal pars distalis. The cavity does not extend completely to the periphery of the gland and in this region the tissues of the pars intermedia and pars distalis are not sharply segregated from one another.

The pars intermedia is composed of closely apposed epithelial diverticula or cords which appear to be related to the hypophysial cavity. Their appearance suggests that the relatively thick intermedia may have been formed by epithelial outgrowths from the adjoining wall of the

cavity. Centrally, the cords or diverticula are interdigitated with the compact fibrous portion of the infundibular process. More peripherally they terminate close to the ependymal lining of the recess. No blood vessels were seen in the pars intermedia but in many instances the pars intermedia tissue is not far distant from the vessels of the infundibular process.

The cells of the intermedia are usually elongated and compactly arranged at right angles to the long axis of the cords, or to the surface of the lumina of the diverticula. The majority of them are lightly basophilic, i.e., react with anilin blue. Some cells react with orange G. These are rounded and tend to be concentrated at the tips of the cords which are embedded in the infundibular process but they may also be scattered along the surfaces of the cords that are separated by fibrous extensions from the process (Fig. 4).

The pars anterior is composed of irregular cords of cells invested by a delicate reticular network. A rich plexus of blood vessels is present. Three types of chromophile cells may be recognized. The basophiles are deeply stained by anilin blue. The acidophiles may be divided tinctorially into two groups. Some react specifically with azocarmine, others with orange G. The granulation in the cells reacting with azocarmine appears slightly coarser than that of the orange-stained cells. The significance of the differential staining of the acidophiles is not known. Chromophobes are relatively scarce.

The different classes of cells are not uniformly distributed throughout the pars anterior. The basophiles tend to be concentrated in a

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Explanation of Figures

Fig. 2. Ventral view of the brain showing the infundibular process (*P.I.*) and caudal flattened anterior lobe (*P.A.*). × 6.

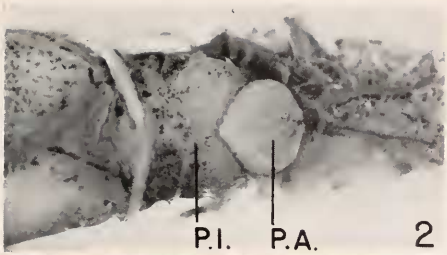
Fig. 3. Area of the thickened wall of the infundibular process showing the fibrous tissue and ependymal lining of the infundibular recess. × 256.

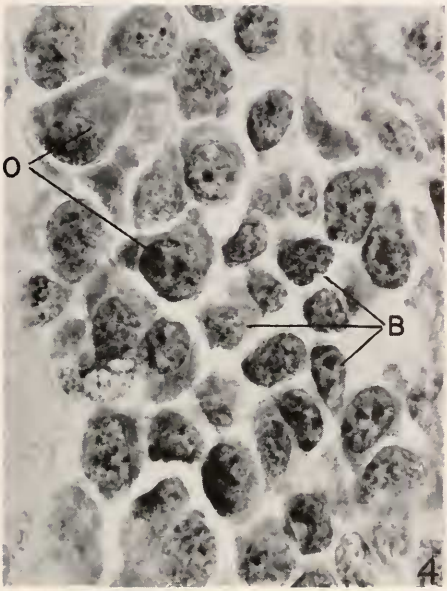
Fig. 4. Tangential section of an epithelial cord of the pars intermedia showing the superficial, rounded, acidophilic cells (*O*) and the deeper elongated basophilic cells cut transversely (*B*). × 768.

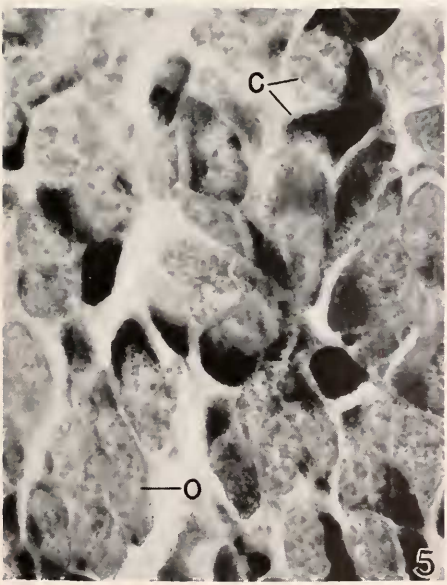
Fig. 5. A group of the elongated acidophiles from a lateral wing of the pars anterior: cells stained with azocarmine appear black (*C*); those stained with orange G are gray (*O*). × 768.

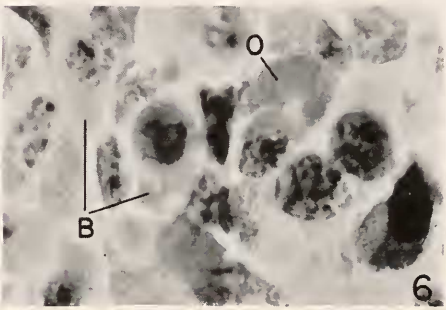
Fig. 6. An area from the median dorsal region of the pars anterior showing the predominance of basophiles (*B*) with occasional acidophiles stained with orange G (*O*). × 768.

Fig. 7. Area from the median, ventral region of the pars anterior showing a group of elongated basophiles and an occasional acidophile (*O*). Erythrocytes in the capillaries are deep black. × 768.









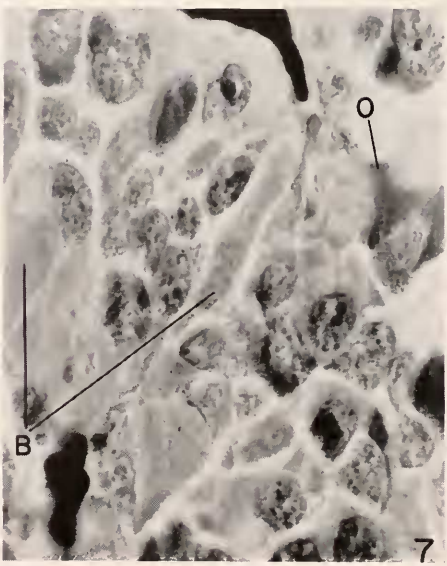


PLATE I

superficial medial band which extends along both the dorsal and ventral surfaces of the pars anterior (Figs. 6, 7). Centrally acidophiles staining with orange G predominate while laterally in the more flattened wing-like extensions the carmine-staining cells are numerous (Fig. 5).

A careful study of complete serial sections of these two specimens failed to reveal any evidence of the presence of a typical pars tuberalis, either attached to the pituitary gland or isolated in the adjoining tissue of the brain. The extreme anterior tip of the pars distalis, as seen in medial sagittal sections, is composed chiefly of lightly basophilic cells with occasional orange G-acidophiles. The location is slightly suggestive of position of the pars tuberalis in urodeles and non-metamorphosed anura but the region is single and median rather than paired. It may, however, only represent a marginal region of incomplete differentiation lacking characteristic basophiles and acidophiles. There is no true saccus vasculosus.

Discussion

The presence of a lumen in the pituitary glands of all three Dipnoi is a matter of interest. In each case the epithelial component develops as a solid ectodermal ingrowth and secondarily acquires a lumen which persists. Furthermore, in the final differentiation of the gland the lumen tends to occupy the position typical of many vertebrates between the pars intermedia and the anterior lobe proper. In *Epiceratodus*, however, some anterior lobe tissue is found on the neural side of the lumen in association with the pars intermedia, but in *Lepidosiren* and *Protopterus* only intermediate tissue is found in this location. The phylogenetic significance of the lumen, in relation to its mode of development, either as a remnant of Rathke's pouch or as a secondary schizo-cavity, has been discussed by de Beer (1926) and Griffiths (1938), but these authors failed to find any adequate explanation of the two modes of origin.

In its general histological appearance, its caudal position and the topographical relations of infundibular process, pars intermedia and pars anterior, the pituitary gland of the Dipnoi closely resembles that of Amphibia. In the Amphibia there is also a solid ectodermal ingrowth, but a lumen is not secondarily developed. Nevertheless, the segregation of intermediate and anterior lobe tissue occurs almost as regularly as when a lumen is present. However, in birds a Rathke's pouch is formed but the lumen disappears early and no definitive pars intermedia is present in the adult gland. The further complications observed in teleosts, elasmobranchs, cyclostomes, *Polypterus* and certain mammals

(manatee, whale and armadillo lack a pars intermedia) throw no light on this general problem but rather tend to increase the confusion.

Some reference should also be made to the position of the pituitary gland in relation to the infundibulum. In *Epiceratodus* the infundibular process extends vertically from the floor of the brain. The anterior lobe is truly anterior to it and the entire gland occupies a deep sella. In *Lepidosiren* the entire gland lies caudal to the infundibular recess with the pars intermedia and pars distalis lying ventral to the thickened dorso-caudal wall of the infundibular process. The gland occupies a shallow sella. In *Protopterus* the infundibular process is directed caudally and the epithelial portion of the pituitary lies almost directly posterior to the process. The entire gland is close to the brain and there is no depression in the floor of the cranium. The developmental factors influencing the orientation of the pituitary gland with reference to the infundibulum are not known.

Summary

This study is based on two male specimens, 14 inches long. The flattened pituitary gland lies close to the brain and is located caudally to the infundibulum. There is no sella turcica in the cranial floor.

In a ventral view of the brain only the infundibular process and the flattened ovoid pars anterior are visible. The infundibular process is wide and thin-walled except in a median ventro-caudal region applied to the pars intermedia, where a considerable thickening occurs. The epithelial portion of the gland possesses a conspicuous hypophysial cavity which almost completely separates an antero-dorsal intermediate zone from a more elongated ventro-caudal pars distalis. The pars intermedia is composed of open or closed epithelial diverticula which are associated with the hypophysial cavity and are interdigitated with the compact fibrous portion of the infundibular process. The pars distalis is composed of cords of epithelial cells.

The majority of the intermedia cells are basophilic but a number of cells reacting with orange G are present, especially in the region immediately in contact with the neural tissue. In the pars distalis chromophobes are rarely seen. After Heidenhain's azan method three types of chromophilic cells may be distinguished, deeply staining basophiles, acidophiles selectively stained with orange G and acidophiles reacting with azocarmine.

There is no pars tuberalis or saccus vasculosus.

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